

# PACIFIC SOUTHWEST

## Forest and Range Experiment Station

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

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### ADAPTABILITY OF SELECTED TREE SPECIES PLANTED IN HAWAII FORESTS

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Many tree species have been introduced into Hawaii from around the world (Bryan and Walker 1962, Hillebrand 1965, St. John 1973). Trial introductions of new species for various forestry purposes began in the 19th century and are still continuing. Walker (1887), Judd (1915), Lyon (1929), Zschokke (1930), Bryan (1947), and Whitesell (1971, 1974), among others, have reported on some of the tree adaptability trials of government agencies and private organizations. But generally, adequate follow-up appraisals of the adaptability of species to the planting sites have not been performed, or at least have not been documented.

Nelson (1965) compiled available information about plantings made by the Hawaii Division of Forestry between 1908 and 1960. This new research developed listings of the species planted, the locations of plantings, and the number of seedlings and dates of plantings. The purpose was to provide a general tabular reference on forest tree species introduced to Hawaii, and to guide field appraisals of selected tree species already introduced on forest sites.

The present report summarizes appraisals of the adaptability of selected species. The appraisals are based on field observations and measurements, and seek to evaluate adaptability, growth, and form. Information on 31 species is presented in tabular form (p. 13), and the Species Notes provide additional comment on each species' characteristics, including its value as sawtimber and its flowering and fruiting habit. Recommendations for further research are also given.

### THE HAWAII SETTING

The characteristics of sites in the Hawaiian Islands, as related to growth of trees and other plants, are markedly varied. These islands, lying in the tropical latitudes of the north central Pacific Ocean, have a mild year-round climate that is strongly affected, however, by the mountainous terrain (Armstrong 1973). Mountains rise to 13,784 feet (4201 m) on one island, to 10,012 feet (3052 m) on another, and to more than 1000 feet (305 m) on all the other main islands. Average annual rainfall ranges from less than 10 inches (250 mm) at some leeward locations to greater than 400 inches (10,000 mm) at other locations. The average temperature at sea level is about

75° F (24° C), decreasing about 3° F (1.7° C) per 1000-foot (305-m) increase in elevation above sea level.

The great diversity of physiographic conditions found in the 4.1 million acres (1.66 million ha) of land in Hawaii includes 190 soil series. All 10 orders of soils recognized in the National Cooperative Soil Survey are represented in Hawaii (Foote and others 1972, Sato and others 1973). Thus, there are many kinds of sites for tree growth, and growing conditions differ markedly within short distances.

Some 800 tree species have been planted throughout the islands, on a wide variety of forest sites, by the Hawaii Division of Forestry (Nelson 1965). Although some native Hawaiian species were planted, most of these were slow growing and difficult to establish on the eroded areas that made up some of the major areas needing reforestation. Therefore, planting was done primarily with exotic tree species. Many were tested through the years, with emphasis on those useful for protecting watersheds. Only recently has much attention been paid to timber-producing potential. The search for suitable species to grow on different sites in Hawaii continues.

### STUDY METHODS

Data on tree planting work done by the Division of Forestry up to 1960 were organized by species name and by locations of plantings. From limited literature review and firsthand knowledge, each listed species was tentatively rated for probable silvical adaptability in Hawaii and for its potential to yield wood products. These preliminary "value" ratings of about 800 species, as well as information on location and number of trees planted, provided the basis for screening the lists, and 60 species were selected for field appraisal.

Plans were to appraise the growth of a given species at 10 locations representing diverse growing conditions, if there were that many plantings. When a planting was located in the field, information on tree, stand, and site attributes was recorded:

*Tree attributes:* Diameter, height, form, crown width, defects, and merchantability potential.

*Stand attributes:* Species composition, spacing, basal area, density, damage, and presence of regeneration.



*Site attributes:* Elevation, precipitation, aspect, slope, soil depth, soil drainage, land use, mapped soil series, and competing vegetation.

Field appraisal work was mostly conducted between 1964 and 1968. Locating the plantings in the field proved to be unexpectedly difficult. The planting records usually mentioned only the forest reserve, which might encompass many square miles. All of the seedlings recorded as planted at one time were not necessarily planted at one site, or in a single block. Some were scattered throughout the areas designated. Even with the aid of local forestry personnel who in some instances had helped plant the trees, relocation success was less than 50 percent.

## RESULTS

Although field appraisal efforts did not yield as much information as initially anticipated, the findings are helpful. Data (p. 13) from field examination of plantings of 31 species were summarized (table 1). Location of plantings appraised is given to the nearest second of latitude and longitude to aid those wishing to see them.

Even though large numbers of seedlings of most species were planted, specific recommendations can be made for very few species on the basis of the appraisal results. Only one, *Juglans nigra*, is considered not adapted to Hawaii. Several are apparently useful only for ornament or protective cover. The adaptability of nine, *Albizia falcataria*, *Araucaria columnaris*, *Eucalyptus deglupta*, *Fraxinus uhdei*, *Grevillea robusta*, *Sequoia sempervirens*, *Swietenia macrophylla*, *Swietenia mahagoni*, and *Toona ciliata* var. *australis*, is sufficiently established to support recommendations on the general site conditions they require in Hawaii. Research is now needed to determine the cultural practices that will produce the best growth and form of these species. For more than half the 31 species examined, however, further site trials are needed before a final decision concerning their adaptability in Hawaii can be made.

Our inability to readily apply the results of the study points up the critical importance of keeping complete records of trials of exotic species. Accurate locational information would have made it possible for us to find a much greater percentage of the plantings, or at least to verify that they had not survived. Detailed records of planting stock condition, planting techniques, weather at time of planting and during the establishment period, and postplanting maintenance treatments, would have made it possible to deduce with some degree of certainty whether failure

or poor performance was caused by one or more of these factors, or by lack of species adaptation. Much more information might thus have been gained from the many plantings made between 1908 and 1960.

## SPECIES NOTES

### *ACACIA MELANOXYLON* R. B. (Leguminosae)<sup>1</sup>

**Blackwood acacia** is indigenous to southeastern Australia, on a wide range of sites. There it develops best in cool rain forest types and grows to heights of more than 120 feet (37 m). In Australia, the wood is considered highly attractive for cabinet and furniture uses; it closely resembles Hawaiian koa (*Acacia koa*).

Thirty plantings are recorded—on Kauai, Oahu, and Maui—totaling some 17,000 seedlings. The earliest planting, of 100 seedlings, was made in 1919 in the Papalolalola Forest Reserve, Kauai. Eight plantings were examined.

Blackwood acacia is well adapted to relatively cool, moist sites in Hawaii. Growth rates have been generally moderate. Some trees have attained heights of over 90 feet (27 m) and diameters breast high of over 20 inches (50 cm) in about 30 years. Although some trees were of excellent form for sawtimber, many were only fair or poor in form because of lateral branching, fluting of trunk, and spiral grain. Root suckering was common. Flowering was observed in April.

Further trials are needed in moist sites at elevations of 2000 to 4000 feet (610 to 1220 m). Equally or more important, research is needed in genetic tree improvement and on the effect of stand density on tree growth and quality.

*References:* Albert 1908, Australia Dep. Natl. Dev. 1962, Francis 1951, Streets 1962.

### *AGATHIS AUSTRALIS* Salisb. (Pinaceae)

**New Zealand kauri** is indigenous to North Island, New Zealand, where it occurs over a wide range of growing conditions. There it reaches heights of 80 to 120 or even 150 feet (24 to 46 m), with long, clear boles and trunk diameters to 7 feet (2.1 m), or even larger. New Zealand kauri wood is recognized worldwide as excellent for many uses, including construction and furniture.

The four plantings recorded, totaling some 850 seedlings, were made on Oahu during 1920 to 1924.

<sup>1</sup> Family designations in this report are based on Dalla Torre and Harms 1900-1907.

Only one planting was located for appraisal. Growth had been generally slow but dominant trees were of excellent form for sawtimber. Fruiting was noted in October. Coppicing was also noted.

This species may offer considerable potential for forestry uses in Hawaii. Further adaptability trials are needed on different sites, especially at elevations above 2000 feet (610 m).

*References:* Hinds and Reid 1957, Parham 1964, Streets 1962.

#### *AGATHIS ROBUSTA* F. M. Bail. (Pinaceae)

Australian kauri or Queensland kauri is indigenous to areas in the vicinity of Maryborough and on Fraser Island, Queensland, Australia. There it occurs as a dominant in some rain forests, attaining heights of more than 140 feet (43 m). The wood is attractive and highly valued for cabinetry and millwork.

Eleven plantings are recorded from 1921 to 1958—on Oahu, Maui, and Hawaii—but totaling only 231 seedlings. Only one small planting was located for appraisal.

Growth had been slow, although tree form was excellent. Fruiting was not noted on these trees although fruiting has been noted on street trees in Hilo and Honolulu.

As this species may offer considerable potential for forestry uses in Hawaii, further trials are needed on different soils.

*References:* Australia Dep. Natl. Dev. 1962, Bryan 1947, Francis 1951, Lanner 1966, Parham 1964, Streets 1962.

#### *AGATHIS VITIENSIS* (Seem.) Drake. (Pinaceae)

Fijian kauri or dakua is indigenous in the rain forests of the Fiji Islands, but is now common only in the interior of the main islands. There, trees reach heights up to 100 feet (30 m) and have straight trunks with diameters to 6 feet (1.8 m). The wood has excellent properties for a wide range of uses including furniture, craft items, and face veneer.

Eleven plantings are recorded from 1951 to 1954—on Kauai, Oahu, and Hawaii—totaling some 600 seedlings. Only two plantings were located for appraisal.

Survival was good in both plantings. The growth and form of the trees planted in the Waiakea Forest Reserve on Hawaii indicated that this species holds

promise for high rainfall sites. Cones were observed on one tree.

Further trials are needed at low and medium elevations on moist sites.

*References:* Fiji Dep. For. 1968, Parham 1964.

#### *ALBIZIA FALCATARIA* Fosberg (Leguminosae)

*Molucca albizzia* or *batai* is indigenous to the Moluccas and New Guinea. In the rain forest climate, early height growth often exceeds 15 feet (4.6 m) per year, but maximum heights are seldom more than 100 feet (30 m). The tree has a broad crown and is said to be shortlived. The wood is pale brown, light in weight, and moderately soft and weak. It is considered a general utility wood for uses not requiring high strength, a hard surface, or fine finish.

More than 80 plantings are recorded—on Kauai, Oahu, Lanai, Maui, and Hawaii—totaling some 138,000 seedlings. The earliest record of planting noted in this survey was of 64 seedlings in Kalihi Valley, Honolulu Forest Reserve, in 1925. Nineteen plantings were examined.

*Molucca albizzia* was found to be well adapted to many different soils from near sea level to at least 1600 feet (488 m) elevation. Survival and growth were inferior, however, on exposed sites or shallow rocky soils where annual rainfall is less than 50 inches (1270 mm). Annual height growth sometimes exceeded 20 feet (6 m) during the first few years after planting. Dominant trees in stands from 25 to 40 years old were about 100 feet (30 m) tall and broad crowned. Form was responsive to spacing. Long, clear main boles had developed at spacings of about 12 feet (3.7 m). Trees in more open stands had shorter main boles. Merchantable lengths of over 64 feet (20 m) were common in the better stands.

*Molucca albizzia* produces abundant seed, and natural regeneration was observed in and near many plantings. The species is a pest in some areas.

Further trials to determine the adaptability of this species to different sites are probably not needed, although its adaptability to sites above 1600 feet (488 m) is not known. Research is needed to determine the effect of stand density on growth, form, and log quality.

*References:* Byran 1947, Gerhards 1966, Parham 1964, Peters and Lutz 1966, Richards 1957, Streets 1962, Walters 1971.

*ALNUS NEPALENSIS* Don. (Betulaceae)

Nepal alder is indigenous throughout the Himalaya region and upper Burma at elevations from 3000 to 9000 feet (900 to 2700 m). On moist sites there, trees in natural stands grow rapidly to heights of 80 to 100 feet (24 to 30 m) with diameters up to 2½ feet (76 cm). This species invades disturbed ground and provides rapid protection from erosion. The wood is considered an easily worked utility wood.

Thirty-five plantings are recorded between 1930 and 1960—on Oahu, Molokai, Maui, and Hawaii—totaling some 43,000 seedlings. The earliest planting, not located in this study, was in 1930 in the Waiahole Forest Reserve, Oahu. Two stands established in the Kohala Mountains on Hawaii were examined and a few trees were observed at other locations.

Nepal alder was found to be well adapted to cool, moist, and very wet sites, at elevations above 2000 feet (610 m). Some trees had attained heights of more than 100 feet (30 m) and diameters of 24 inches (60 cm) in about 25 years on the very wet, foggy sites in the Kohala Mountains. Merchantable log lengths of 32 to 48 feet (10 to 15 m) were common, although many stems had sweep and persistent branches. On some sites windfall was common.

Nepal alder produces viable seed and natural regeneration has been observed.

Further trials are needed to determine the adaptability of Nepal alder to moist and wet sites at elevations above 3500 feet (1070 m). This species is not wind hardy and should not be planted on exposed sites or to enhance recreation areas. Research is also needed to determine the effect of stand density on growth, form, and log quality.

*References:* Bryan 1947, Gerhards 1964, Peters and Lutz 1966, Streets 1962, Troup 1921, Whitesell and Isherwood 1971.

*ARAUCARIA COLUMNARIS* (Forst.) Hook.  
(Pinaceae)

Columnar araucaria or Cook's araucaria is indigenous to New Caledonia and the Isle of Pines, where it grows to heights of over 130 feet (40 m). The wood is reported to have properties similar to *A. heterophylla* and *A. cunninghamii* which are excellent for many uses.

Fifty-three plantings are recorded between 1917 and 1960—on Kauai, Oahu, Maui, and Hawaii—totaling some 22,000 seedlings.<sup>2</sup> The earliest re-

corded plantings were in Manoa Valley, Oahu. Trees at eight locations were examined.

The species was found to be well adapted on a wide range of sites to above 2000 feet (610 m). Many trees attained heights of 80 feet (24 m) in about 40 years and some were over 100 feet (30 m) tall. Diameters breast high of measured dominant trees about 40 years old ranged from 13 to 24 inches (33 to 61 cm). There were few heavy branches and little forking to affect merchantable length, but persistent whorls of small limbs on nearly the entire bole adversely affected log quality.

Cook's araucaria produces viable seeds in Hawaii. Fruiting is much more abundant in some years than others. Cones ripen and dehisce in late summer or early fall (August to October).

Natural regeneration was found in and adjacent to most plantings examined. Exceptions were the wet site on the island of Hawaii, where no flowering or fruiting was noted, and the dry sites at Lualualei where fruiting was noted but no seedlings were seen.

Further site adaptability trials are probably not needed. However, as this species has considerable potential for use in Hawaii, research in cultural methods is needed to develop prescriptions for seedling production, planting methods, fertilizers, and weed control on different sites, and the effects of stand density, thinning, and pruning on growth and log quality. Research should include determining relationships between growth rates and site factors such as soil and elevation.

Cook's araucaria has potential for much greater use for Christmas trees, windbreaks, recreation site enhancement, landscape plantings, and timber. Litter production in older, dense stands seems to be ideal to protect the soil from erosion in the absence of understory vegetation.

*References:* Bryan 1947, Gerhards 1967, Neal 1965, Ntima 1968, Streets 1962.

*ARAUCARIA CUNNINGHAMII* Sweet. (Pinaceae)

Hoop pine is indigenous to New Guinea and to the coastal ranges of Queensland and northern New

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<sup>2</sup> Differentiation between *A. columnaris* (Syn. *A. cookii* R. Br.) and *A. heterophylla* (Syn. *A. excelsa* R. Br.) may not have been consistent in the planting records. Probably some of the many plantings recorded as *A. heterophylla*, a species not included in this appraisal, are in fact *A. columnaris*.

South Wales. It occurs from near sea level to 8000 feet (2438 m) elevation in New Guinea and to 3000 feet (914 m) in Australia. In its native habitats it is a large tree, commonly attaining heights of over 150 feet (46 m) and diameters of over 4 feet (122 cm). Mature trees have clear boles yielding timber of excellent working qualities and useful for many purposes.

Thirteen plantings are recorded between 1929 and 1959—on Kauai, Oahu, Molokai, and Hawaii—totaling some 8600 seedlings. Observations and measurements of trees in two plantings located showed that growth had been slow and the trees are of low vigor.

As hoop pine may be a valuable species for various forestry purposes in Hawaii, further trials on a wider range of sites are needed.

*References:* Australia Dep. Natl. Dev. 1962, Bryan 1947, Francis 1951, Neal 1965, Ntima 1968, Streets 1962.

*BRACHYCHITON ACERIFOLIUM* F. Muell.  
(Sterculiaceae)

**Flame tree** is indigenous to the coastal rain forests of New South Wales and Queensland, Australia. There it grows to heights of 120 feet (37 m) and stem diameters of 3 feet (91 cm). It is reported to grow well on sites suited for macadamia nut (*Macadamia integrifolia*) trees. The pale-colored wood is very soft and suitable only for plywood corestock or other products where strength and natural durability are not important. Flame tree is reported to be an attractive ornamental and shade tree. It has been successfully introduced to some areas of Africa.

Twenty-nine plantings are recorded, between 1921 and 1957—on Oahu, Molokai, Maui, and Hawaii—totaling some 4100 seedlings. Only one planting was located for this appraisal—a single tree planted in 1953. It was of poor vigor and form. Although flame tree may be suited for ornamental plantings in Hawaii, forest plantings are not recommended.

*References:* Francis 1951, Neal 1965, Streets 1962.

*CALLITRIS CALCARATA* A. Cunn. ex Mirb.  
(Pinaceae)

**Black cypress-pine** is indigenous to Australia, occurring in Queensland, New South Wales, and Victoria, where it reaches heights to 80 feet (24 m) and

diameters to 18 inches (46 cm). The dark, attractive wood finishes well and is valued for furniture, paneling, and trim work. It is also durable and termite resistant and is useful for posts and poles.

Seven plantings are recorded between 1933 and 1959—on Kauai, Maui, and Hawaii—totaling about 4500 seedlings. Only one planting was located for appraisal. This planting, on Maui in 1949, was of 4245 seedlings. Survival was fair, but growth of the best trees was only moderate. Continuing mortality indicated that the species is not adapted to the moderately moist site. Fruit was noted in November, but no flowers or reproduction.

Further adaptability trials are needed on drier or higher sites, as this species offers potential for ornamental use as well as timber.

*References:* Bryan 1947, Streets 1962.

*CALLITRIS GLAUCA* R. Br. (Pinaceae)

**White cypress-pine** is indigenous to Australia, occurring over a wide range of inland areas with annual rainfall from 14 to 28 inches (360 to 710 mm). There it commonly attains heights of 70 feet (21 m), or on the better sites, grows to 100 feet (30 m) with diameters to 3 feet (91 cm). The yellow-to-brown wood is reported to be of moderate strength and brittle. It is highly resistant to termites and useful for poles, posts, and construction lumber.

Eleven plantings are recorded between 1931 and 1957—on Oahu, Maui, and Hawaii—totaling some 1300 seedlings. The earliest plantings, in 1931, consisted of six seedlings planted in the Waihou Spring Forest Reserve, Maui, and six seedlings planted in the Kohala Forest Reserve, Hawaii. Only two plantings were located for appraisal.

Growth was slow and vigor low on a wet site, but much better on a rocky slope under lower rainfall. Tree form indicated good potential as sawtimber, although limbs were retained on the bole. Fruiting was noted in October at the drier location.

This species should be tested on sites more nearly like its native habitat, that is, drier sites from 1000 to 4000 feet (305 to 1220 m) elevation and avoiding wet, heavy-textured soils. It has potential as an ornamental and for watershed protection and timber production on drier sites.

*References:* Australia Dep. Natl. Dev. 1962, Bryan 1947, Streets 1962.



*CALOPHYLLUM BRASILIENSE* Camb. (Guttiferae)

**Maria** is native to the moist forest areas of Puerto Rico, and with its geographic varieties, is widely distributed throughout the West Indies and adjacent continental areas. There it grows to heights of over 65 feet (20 m) and diameters of 18 inches (46 cm) or more. Maria is commonly planted as an ornamental or shade tree. It is reported to be readily regenerated by direct seeding and to be adapted to degraded sites. The wood is attractive, resembling mahogany, but is more difficult to process.

Eight plantings are recorded—all on Maui between 1929 and 1932—totaling 295 seedlings. Only one planting was located for this appraisal. Dominant trees 34 years old were about 40 to 55 feet (12 to 17 m) tall and less than 15 inches (38 cm) diameter breast height. Short stature and crooked or forked boles indicated their potential for sawtimber was poor on this extremely wet site.

Trees were not flowering in June, but there were fruit and natural seedling regeneration. Some root and stem suckers were seen on windfalls.

Further tests of Maria are needed on different sites, especially to determine its adaptability to degraded sites. Before such tests are made, species identity should be confirmed.

*References:* Little and Wadsworth 1964, Neal 1965.

*CASTANOSPERMUM AUSTRALE* A. Cunn.  
(Leguminosae)

**Moreton-Bay-chestnut** is indigenous to New South Wales and Queensland, Australia, occurring in coastal rain forests and as far as 100 miles (161 km) inland. In its native habitats it is a large tree, reaching 130 feet (40 m) in height and 4 feet (122 cm) in stem diameter. The dark brown timber is considered one of the most attractive cabinet woods of Australia.

Twenty-four plantings are recorded between 1927 and 1957—on Kauai, Oahu, Maui, and Hawaii—totaling some 1200 seedlings. Only one planting was located for this appraisal, in the Ewa Forest Reserve, Oahu.

Survival was poor. Only three plants were seen, out of some 413 reported planted in 1927. Growth of surviving plants had been very slow, indicating the species is not adapted to that site. A large, vigorous specimen over 50 years old, growing as a yard tree in Kukuihaele, and the rapid growth of trees planted in 1967 in an experimental plot above Paauilo, island of

Hawaii, are evidence that the species may be adapted to some moist sites in Hawaii. The tree at Kukuihaele produces viable seed. Flowering was observed in October.

Further trials are needed on moist, well-drained sites.

*References:* Francis 1951, Streets 1962.

*CEDRELA ODORATA* L. (Meliaceae)

**Spanish-cedar** is indigenous in lowland wet forests of tropical America—West Indies to Trinidad and Tobago; and Mexico, Ecuador, Peru, Brazil, and the Guianas. There, on good sites it is a large tree, reaching heights of more than 120 feet (37 m) and stem diameters of over 4 feet (122 cm). The wood is valued for its excellent working qualities and is used for high quality furniture, cabinetry, aromatic chests, trim, veneer, and general construction.

Thirty-two plantings are recorded between 1924 and 1959—on Kauai, Oahu, Molokai, Maui, and Hawaii—totaling more than 26,000 seedlings. The earliest planting was of 200 seedlings in Makiki Valley, Oahu. Only two plantings were located for this appraisal.

Survival rate was low on these sites but growth of surviving trees had been generally good. Dominant trees in the 41-year-old stand in Makiki Valley were more than 80 feet (24 m) tall with stem diameters greater than 2 feet (61 cm). Trees examined in the planting on Maui had similar growth rates. Trees in Hawaii have produced viable seed.

Further trials of this species are needed, especially to test tree and stand development in well-stocked stands.

*References:* Bryan 1947, Lamb 1968, Little and Wadsworth 1964, Streets 1962.

*CINNAMOMUM CAMPHORA* (L.) Nees & Eberm.  
(Lauraceae)

**Camphor-tree** is indigenous to eastern Asia, including Taiwan and Japan. There it is reported to grow best at higher elevations in the tropics or subtropics, reaching heights of 100 feet (30 m) and diameters over 2 feet (61 cm) in forests in Taiwan. On most sites it is much smaller. It is commonly planted for windbreaks or as an ornamental and is also cultivated for production of camphor oil from leaves and twigs.

The fragrant wood is used for chests.

Twenty-seven plantings are recorded between 1919 and 1951—on Kauai, Oahu, and Maui—totaling some 3600 seedlings. Only one planting was relocated for this appraisal.

Survival was about 60 percent of some 500 trees planted. The 32-year-old trees were less than 50 feet (15 m) tall with stem diameters at breast height of up to 10 inches (25 cm). Some had straight stems but many were crooked or forked. No flowers, fruit, or seedlings were observed.

Camphor-tree should be tested further for adaptability and growth in Hawaii at elevations above 3000 feet (900 m) on moist, well-drained sites.

*References:* MacMillan 1952, Neal 1965, Streets 1962.

#### *ENTEROLOBIUM CYCLOCARPUM* (Jacq.) Gris.

(Leguminosae)

Guanacaste or earpod is indigenous to the West Indies, Central America, and northern South America. There it is a fast-growing, large tree, reaching heights of 130 feet (40 m) and stem diameters over 6 feet (1.8 m). It is an attractive shade tree. The timber is suitable for furniture and general carpentry, closely resembling the wood of monkey-pod (*Pithecellobium saman* [Jacq.] Benth.).

Thirty-five plantings are recorded between 1923 and 1949—on Kauai, Oahu, Maui, and Hawaii—totaling some 16,000 seedlings. Four plantings were located for this appraisal, all on the island of Maui.

Survival was low in most plantings, but growth had been moderate to fast. Some 30-year-old trees measured were more than 100 feet (30 m) tall and had diameters at breast height greater than 3 feet (91 cm).

The potential for growing this timber tree in Hawaii should be determined by establishing well-stocked stands on moist deep soils where rainfall is greater than 70 inches (1780 mm).

*References:* Bryan 1962, Neal 1965, Rock 1920, Streets 1962.

#### *EUCALYPTUS DEGLUPTA* Blume (Myrtaceae)

Bagras eucalyptus is indigenous to New Guinea, New Britain, the Molucca Islands, and Mindanao in

the Philippine Islands. It is a rain forest tree growing to heights of more than 200 feet (61 m) and diameters breast high of more than 6 feet (1.8 m). On well-drained alluvial soils early growth is extremely rapid. Bagras timber is lighter in weight than that of most eucalypts. The reddish-brown wood machines and seasons well and is useful for construction and cabinet work.

Bagras eucalyptus is an attractive tree and in recent years, has been used for landscaping in urban areas in Hawaii. Twenty-eight plantings are recorded between 1945 and 1958—on Kauai, Oahu, Molokai, Maui, and Hawaii—but totaling only about 4200 seedlings. Six plantings were examined.

Adaptability and growth were variable, depending on site conditions. Trees planted at low elevations on well-drained soils in areas of high rainfall had grown rapidly and developed long, clear boles. In one planting, some 13-year-old trees were 90 feet (27 m) tall and more than 12 inches (30 cm) d.b.h.

Intensive silvicultural research should be initiated with this species on moist, well-drained sites at low elevations in Hawaii. Its use for urban area landscaping should also be studied. Its rapid growth to large sizes on some sites may cause problems in urban areas.

*References:* Davidson 1973, Kraemer 1951, Penfold and Willis 1961, Streets 1962.

#### *FLINDERSIA BRAYLEYANA* F. Muell. (Rutaceae)

Queensland-maple is indigenous in the rain forests of Queensland, Australia. There it grows to 100 feet (30 m) tall and may have a stem diameter of over 4 feet (1.2 m). The attractive wood processes well and is highly valued and extensively used for fine furniture and cabinetry.

Twenty-one plantings are recorded, two in 1935 and the others between 1957 and 1960—on Oahu, Molokai, and Hawaii—totaling about 3800 seedlings. Three plantings were located for this appraisal.

Although survival and growth were variable, the rapid growth and good form of many individual trees indicated that Queensland-maple has good potential for timber production on a range of sites. On Oahu sites, dominant trees reached heights of over 70 feet (21 m) and diameters breast high of nearly 20 inches (50 cm) in 30 years. On the island of Hawaii, some 13-year-old trees were 80 feet (24 m) tall with diameters of 12 inches (30 cm).

Further experimental plantings of Queensland-

maple should be made to determine the sites to which it is best adapted, and also to determine growth and development of well-stocked stands.

*References:* Burgan and Wong 1971, Francis 1951, Neal 1965, Streets 1962.

*FRAXINUS UHDEI* (Wenzig) Lingelsh. (Oleaceae)

**Tropical ash** is indigenous in Western and Southern Mexico and Guatemala. A medium-size tree there, it grows to 60 feet (18 m) in height and 16 inches (40 cm) in trunk diameter. It is reported to grow along stream banks. Tropical ash is a popular street and shade tree in Mexico City, Guadalajara, and elsewhere. The light-colored, yellowish wood is moderately heavy and strong and is well-suited to furniture and cabinet work. It does not have the toughness and strength required for tool handles.

More than 125 plantings of tropical ash are recorded between 1924 and 1960—on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii—totaling over 294,000 seedlings. The 14 plantings located for this appraisal included four on the island of Lanai which were not listed in the records surveyed. There is confusion about the identity of species in the *Fraxinus* plantings. Many were recorded as *F. americana* when planted, but botanists who have studied specimens indicate that the Hawaii plantings are probably all *F. uhdei*.

Tropical ash grew best in Hawaii on moist sites with well-drained soils at elevations between 1500 and 5000 feet (457 to 1524 m). Survival was low, growth slow, and form scrubby on relatively dry sites on ridges and side slopes on the island of Oahu. On Lanai island, under similar rainfall, but on alluvial soils, growth and form were better. Trees 37 years old reached 100 feet (30 m) in height and more than 2 feet (61 cm) in trunk diameter. The tendency for low forking, development of multiple stems, or lodging was a drawback in terms of potential timber production. Nevertheless, some young stands produced sawtimber at rates greater than 1000 board feet per acre (14 m<sup>3</sup> per ha) per year.

Tropical ash trees produce abundant viable seed in Hawaii and natural regeneration is occurring.

Further research is needed on the silvics of this species and the cultural practices needed for optimum stand development. Genetic tree improvement research should also be initiated.

*References:* Neal 1965, Pickford and LeBarron 1960,

Standley and Williams 1969, Whitesell and others 1971, Youngs 1960.

*GREVILLEA ROBUSTA* A. Cunn. (Proteaceae)

**Silk-oak** is indigenous to the rain forests of Queensland and New South Wales, Australia, where it attains heights of 120 feet (37 m) and trunk diameters of 3 feet (91 cm). The attractive yellowish wood with distinctive ray pattern is valued for cabinetry. The tree has attractive foliage and flowers and is widely planted for shade and landscaping.

Two hundred and seventy plantings, totaling more than 2.2 million seedlings are recorded between 1910 and 1959—on Kauai, Oahu, Molokai, Maui, and Hawaii.

Silk-oak is adapted to a broad range of sites in Hawaii. It has become naturalized over thousands of acres, mostly below 1000 feet elevation. It grows moderately rapidly and attains fair form for sawtimber at elevations from near sea level to over 3000 feet (914 m) and under a range of annual rainfall from 35 inches (890 mm) to over 175 inches (4450 mm). Silk-oak is considered by some landowners to be a noxious weed on pasture lands.

Further research on the adaptability of silk-oak to various sites in Hawaii is probably not needed. However, research on silvicultural practices will be beneficial as this species has good potential for timber production.

*References:* Francis 1951, Nelson 1960, Streets 1962.

*INTSIA BIJUGA* (Colebr.) O. Kuntze (Leguminosae)

**Ipil** is indigenous over a wide area, from the coast of East Africa through Southern Asia, the Malay Archipelago, New Guinea, Fiji, and some other Pacific Islands. It is best adapted to areas just inland from the shoreline or to moist alluvial flats where it reaches heights up to 100 feet (30 m) and stem diameters up to 3 feet (91 cm). The reddish-brown, coarse-textured wood is very heavy but seasons well. Although the wood is not as easily worked as some hardwoods, its durability, high strength, and low shrinkage make it highly useful for flooring and special structural purposes.

Nine plantings are recorded between 1917 and 1947—on Oahu and Maui—totaling only 285 trees, however. None of these recorded plantings were lo-

cated in this appraisal. The one planting found and appraised was on a slope, not typical of soils to which ipil is naturally adapted. Nevertheless, 30-year-old trees had grown to 86 feet (26 m) in height and 20 inches (51 cm) d.b.h.

The potential of this species in Hawaii should be tested by establishing well-stocked, experimental stands on moist, alluvial soils at elevations no higher than 1000 feet (305 m).

*References:* Fiji Dep. For. 1968, Kraemer 1951, Rock 1920, Streets 1962.

#### *JUGLANS NIGRA* L. (Juglandaceae)

**Black walnut** is indigenous to the Central and Eastern United States of America and Southeastern Canada. Best adapted to deep alluvial soils, it grows to over 100 feet (30 m) tall with stem diameters greater than 3 feet (91 cm). Black walnut wood is highly valued and is in great demand for furniture manufacture, paneling, and craftwood. The tree is also grown as an ornamental and for nuts.

Twenty plantings are recorded between 1932 and 1947—on Maui and Hawaii—totaling 1620 trees. Three plantings were located for this appraisal. Low survival, slow growth, and inferior form and vigor of trees indicated that black walnut is not adapted to Hawaii sites.

*Reference:* Harlow and Harrar 1937.

#### *LAGERSTROMELA SPECIOSA* (L.) Pers. (Lythraceae)

**Giant crapemyrtle** or **queen flower** is indigenous to the India-Ceylon-Malayan region. It is a medium-size tree, attaining heights of about 50 feet (15 m). It has been widely planted as an ornamental because it provides a strikingly beautiful seasonal show of purplish blossoms. It is reported to grow best in moist low areas where annual rainfall exceeds 60 inches (1520 mm). Wood of giant crapemyrtle is hard and durable and is highly valued for special uses such as boat building.

Twenty-four forest plantings are recorded between 1926 and 1957—on Oahu, Molokai, Maui, and Hawaii—totaling about 5200 seedlings. Nearly 3600 of these were planted in 1937 in the Honouliuli Forest Reserve, Oahu, but were not found during this study. Two plantings were located for this appraisal,

both on Maui. Survival of this species was not good on the sites planted and growth and form of surviving trees indicated it has little potential for timber. Any further tests should be confined to areas of deep, well-drained soils with annual rainfall of 50 to 100 inches (1250 to 2500 mm). Where it can be cared for, this species can be grown as an ornamental in Hawaii.

*References:* Little and Wadsworth 1964, MacMillan 1952, Neal 1965, Streets 1962.

#### *PLATYMISCIUM STIPULARE* Benth. (Leguminosae)

**Roble** is indigenous to Central and South America. It is reported to be a medium-to-large tree in native forests, and is an attractive ornamental, producing a profusion of yellow flowers. The wood is red, hard, and heavy, and is useful for furniture and other products.

Nineteen plantings are recorded between 1937 and 1959—on Oahu, Molokai, and Maui—totaling 5600 seedlings. More than half of these were planted in the Waianae Mountains, island of Oahu, in 1937. Four plantings were examined.

Adaptability of roble to Hawaii sites varied. Where survival was relatively high, growth had been moderate or slow and the form of the tree for timber was generally inferior. The largest trees measured were 29 years old, 60 to 80 feet (18 to 24 m) tall and 12 to 15 inches (30 to 38 cm) d.b.h.

More information about the microsites where these larger trees are growing would be useful to assess the potential for further trials of this species as an ornamental or as a timber tree.

*References:* Menninger 1962, Neal 1965, Record and Hess 1943, Rock 1920.

#### *PODOCARPUS IMBRICATUS*<sup>3</sup> Blume (Taxaceae)

**Java podocarpus** is indigenous to a broad trans-equatorial region of the Western Pacific, occurring from near sea level to nearly 10,000 feet (3000 m) elevation. Its growth is variable in its natural range but on some sites it grows to 150 feet (46 m) tall. It is considered a valuable timber species, the wood being used for furniture, construction, and carvings.

<sup>3</sup> Syn. *P. cupressina* R. Br.



Sixteen plantings totaling only 460 seedlings are recorded between 1924 and 1958, on Oahu, Molokai, and Hawaii. The earliest planting, of 10 seedlings, was at Puu Kauku on the island of Hawaii. Three plantings were relocated for this appraisal.

Growth of the trees in one planting, at 1700 feet (518 m) elevation and with an annual rainfall of about 200 inches (5000 mm), indicated that there is potential for this species as a timber tree in Hawaii. Although growth had been slow, averaging only 1 to 2 feet (30 to 60 cm) in height per year, the form of the trees was good. The species is reproducing naturally from seed in the vicinity of the planted trees. Appraisal of 22-year-old trees at a site at 5100 feet (1550 m) showed little potential for the species there. Java podocarpus also has potential for use in landscaping.

Further trials are needed on different soils. Trials should probably be restricted to sites below 4000 feet (1200 m) elevation.

*References:* MacMillan 1952, Parham 1964, Richmond 1965.

*SEQUOIA SEMPERVIRENS* (D. Don) Endl.  
(Pinaceae)

**Redwood** is indigenous to the coastal areas of northern California and the extreme southwest corner of Oregon. It occurs where annual rainfall is as low as 25 or as high as 122 inches (630 to 3100 mm), but it is restricted to areas having heavy summer fogs. On some alluvial bottomland sites, redwood trees attain heights greater than 300 feet (91 m). The tallest redwood on record is 368 feet (112 m), the tallest tree in the world. Redwood timber is lightweight, soft, easily worked and highly valued for its great durability. It is much preferred for siding, paneling, stakes, and posts where durability is important.

Eighty-four plantings are recorded between 1919 and 1960—on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii—totaling more than 130,000 seedlings. Nine plantings were examined.

On a few sites redwood plantings had high survival and moderately rapid growth. These were areas of well-drained soils lying above 3000 feet (914 m) elevation and having a high incidence of fog. On these sites, some trees reached heights greater than 110 feet (34 m) and were more than 30 inches (76 cm) d.b.h. after 37 years. Experience has demonstrated that seedling establishment is difficult because of competition of other vegetation, as growth of planted seedlings is slow for the first few years.

Redwood is an excellent species for forestation of moist, mid-elevation sites in Hawaii, especially areas where fog is frequent.

*Reference:* USDA Forest Service 1965.

*SWIETENIA MACROPHYLLA* King (Meliaceae)

**Honduras mahogany** is indigenous to tropical America from Southern Mexico to Northern South America. It is a large forest tree attaining heights to 130 feet (40 m) and diameters of 6 feet (1.8 m) on deep, fertile, alluvial soils. Because Honduras mahogany timber is one of the most highly valued cabinet woods of the world, this species has been planted extensively in many tropical areas, to develop timber resources and also as an ornamental or shade tree.

Thirty-four plantings are recorded between 1928 and 1960—on Oahu, Molokai, Maui, and Hawaii—totaling about 7000 seedlings. Three plantings were located for this appraisal.

Survival was good and growth had been moderately rapid. In one planting, on Oahu, trees were up to 88 feet (27 m) in height and up to 20 inches (51 cm) in trunk diameter after 22 years. At the Fleming planting on Maui, 30-year-old trees were as much as 85 feet (26 m) tall. Some trees exceeded 14 inches (36 cm) in diameter. Natural regeneration was present in this stand.

Honduras mahogany appears to be well adapted to moist sites in Hawaii. It should be planted only on deep well-drained soils of lower slopes or valley bottoms. Plantings should probably be restricted to areas below 1000 feet (300 m) elevation.

Research is needed to develop specific knowledge about the site requirements and cultural practices needed to grow this valuable tree for timber crops in Hawaii.

*References:* Bryan 1947, Little and Wadsworth 1964, Record and Hess 1943, Streets 1962.

*SWIETENIA MAHAGONI* Jacq. (Meliaceae)

**West Indies mahogany** is indigenous to southern Florida, the Bahamas, Cuba, Jamaica, and Hispaniola. It is a medium-size to large forest tree, attaining heights to 100 feet (30 m) and diameters greater than 4 feet (1.2 m) on the best sites. West Indies mahogany is considered to be the world's premier cabinet

wood. It has been planted in many tropical areas of the world to develop timber resources. It is also an attractive ornamental and shade tree.

Thirty-seven plantings are recorded between 1918 and 1958—on Kauai, Oahu, Molokai, Maui, and Hawaii—totaling nearly 12,000 seedlings. Six plantings were located for this appraisal.

The high variation in survival and growth of trees in different plantings probably indicates that West Indies mahogany is not adapted to most sites in Hawaii. Nevertheless, it can be recommended for forest plantings on deep, well-drained soils at elevations below 1000 feet (300 m) where annual rainfall is greater than 60 inches (1520 mm). It is also recommended as a street or shade tree.

Research should determine what specific site factors and cultural practices are required to grow this valuable tree for timber crops in Hawaii.

*References:* Bryan 1947, Little and Wadsworth 1964, Record and Hess 1943, Streets 1962.

*TABEBUIA DONNELL-SMITHII* Rose  
(Bignoniaceae)

*Primavera* is indigenous to Southern Mexico and Central America. It is a large tree, growing to heights of 80 feet (24 m) or more and trunk diameters of 4 feet (1.2 m). *Primavera* is also called gold tree because of its show of yellow flowers. Its striking beauty in bloom makes it a highly desired tree for landscaping. *Primavera* is also prized for its timber. The light yellowish or pale brown wood is useful for furniture, cabinetry, and paneling, being easily worked and finished and dimensionally stable. Commercial supplies are scarce.

Eighteen plantings totaling only 1200 seedlings are recorded between 1923 and 1958, on Kauai, Oahu, Maui, and Hawaii. Only one small planting was re-located for this study.

Trees in this planting had heights to 55 feet (17 m) and stem diameters to 20 inches (51 cm) at 40 years of age. Because these trees were planted at wide spacing and were open-grown, appraisal of timber production potential is not possible. *Primavera* trees are growing quite well as street plantings and landscape specimens at many low elevation locations in Hawaii.

Further trials should be conducted to determine the adaptability of *primavera* to higher elevations, on typical forest sites.

*References:* Kukachka 1958, Neal 1965, Record and Hess 1943.

*TERMINALIA MYRIOCARPA* Heurick & Meull.-Arg.  
(Combretaceae)

*Jhalna* is indigenous to India. It is reported to be a large tree there, having long, clear boles with diameters to 6 feet (1.8 m). It is an attractive tree when in flower or fruit. *Jhalna* wood is dark brown, finishes well and is classified as a medium-weight utility wood.

Sixty-four plantings totaling over 26,000 seedlings are recorded between 1928 and 1958, on Kauai, Oahu, Maui, and Hawaii. Eight plantings were located for this appraisal.

Survival was good and growth rate had been moderate on a broad range of relatively moist sites. But the form of the tree for timber production was generally inferior. Although occasional trees were single-stemmed, most were multistemmed from near the base. *Jhalna* was regenerating naturally and in some instances this "second-growth" had better form than the planted trees.

*Jhalna* has no special known attributes for extensive forestry use in Hawaii. Further trials with the species are not recommended. However, as it is attractive and seems adapted to a broad range of moist sites, it should be considered a candidate for some forestry plantings and for landscaping.

*References:* Brandis 1907, Bryan 1947, Neal 1965, Sekhar and Sharma 1966.

*TOONA CILIATA* var. *AUSTRALIS* (F. Muell.)  
C. DC. (Meliaceae)

*Australian toon* is a large tree indigenous to New South Wales and Queensland, Australia. There, in the coastal rain forests, it attains heights to 140 feet (43 m) and trunk diameters to 6 feet (1.8 m). The reddish brown wood is attractive and is reported to be durable. It seasons well, and is highly valued for manufacture of furniture, cabinetry, and paneling.

More than 170 plantings are recorded between 1917 and 1960—on Kauai, Oahu, Molokai, Lanai, Maui, and Hawaii—totaling some 190,000 seedlings. Trees at 17 locations were appraised.

*Australian toon* is adapted to a wide range of sites. On widely differing sites, trees were more than 100 feet (30 m) tall and had stem diameters greater than 2 feet (61 cm) after 30 to 40 years. Adaptability and growth were good on sites up to 3500 feet (1067 m) elevation. A planting at 5300 feet (1615 m) indicated the species is not adapted to that elevation. Aus-

tralian toon should not be planted on soils having poor drainage. In areas where annual rainfall is less than 50 inches (1270 mm), plantings should be made only on deep soils or lower-slope topographic positions.

Australian toon produces viable seed in Hawaii. Natural regeneration is occurring in and adjacent to many plantings examined.

Further site adaptability trials are probably not needed. However, as this species has considerable potential for enhancing the forest resources in Hawaii, research in cultural methods is needed. Prescriptions

need to be developed for seedling production, planting methods, fertilizers, and weed control on widely different sites. Research should include detailed investigations of the relationship of growth rates to soil and other site factors. And the effects of stand density, thinning, and pruning on timber yield and quality should be determined.

*References:* Bryan 1947, Francis 1951, Pickford and LeBarron 1960, Streets 1962, Wick and Burgan 1970, Wick and others 1971, Youngs 1960.

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Table 1--Forest tree plantings appraised for species adaptability to Hawaii

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			<u>Feet</u>	<u>Inches</u>						
Acacia melanoxylon (30 P, 17,000 S; K,O,M; 1919-51)										
Kauai	22°08'00"	159°38'40"	3600	45	Kokee	ca.1935	4 acres	Good	Moderate	Fair
	22°08'12"	159°38'35"	3700	70	Kunuweia	ca.1935	4 acres	Good	Moderate	Fair
	22°07'55"	159°39'05"	3600	60	Kokee	ca.1950	4 acres	Good	Moderate	Fair
	22°07'30"	159°39'55"	3600	55	Kokee	ca.1935	4 acres	Fair	Moderate	Fair
Maui	20°41'02"	156°20'15"	5200	45	Kaipoiol	1936	462	Poor	Moderate	Fair
	20°50'55"	156°17'12"	2100	75	Olinda	1932	1,000	Fair	Moderate	Inferior
	20°48'18"	156°17'11"	3700	55	Olinda	1934	106	Fair	Moderate	Fair
	20°46'37"	156°13'55"	6400	75	Kaipoiol	1951	2,520	Poor	Slow	Inferior
Agathis australis (4 P, 850 S; O; 1920-24)										
Oahu	21°28'10"	157°52'10"	300	90	Waikane	1920	780	Fair	Slow	Excellent
Agathis robusta (11 P, 231 S; O,M,H; 1921-58)										
Hawaii	19°40'10"	155°04'00"	100	150	Papai	1936	67	Good	Slow	Excellent
Agathis vitiensis (11 P, 593 S; K,O,H; 1951-54)										
Hawaii	19°37'31"	155°08'25"	1500	200	Kiloe	1952	468	Good	Moderate	Excellent
	20°04'44"	155°33'30"	2200	80	Honokaa	1952	24	Good	Slow	Excellent

(Continued)

<sup>1</sup>Planting history is given after species name: P = number of plantings, S = number of seedlings; initials indicate islands: H--Hawaii; K--Kauai; L--Lanai; M--Maui; Mo--Molokai; O--Oahu.

<sup>2</sup>Soil classification determined from soil maps (Foote and others 1972, Sato and others 1973). It must be recognized that soil at the spot where the trees were growing may not be the soil as mapped, because of mapping intensity and inclusions.

<sup>3</sup>Where ca. appears, records indicate that this date is probably within 5 years of the actual date.

<sup>4</sup>Adaptability is shown as follows: Good = Greater than 70 percent survival or stocking; Fair = 40 to 70 percent survival or stocking; Poor = Less than 40 percent survival or stocking.

<sup>5</sup>Height growth is shown as follows: Fast = Greater than 5 feet per year; Moderate = 2 to 5 feet per year; Slow = Less than 2 feet per year.

<sup>6</sup>Form is shown as follows: Excellent = Long straight clean bole; Fair = Will likely produce more than one sawlog but has heavy or persistent branches; Inferior = Will not likely produce more than one sawlog or is extremely limby or forked.



Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			Feet	Inches						
Albizia falcataria (84 P, 138,000 S; K,O,L,M,H; 1925-55)										
Oahu	21°18'50"	157°46'55"	600	60	Lolekaa	1950	150	Good	Fast	Fair
	21°20'15"	157°49'10"	1600	120	Cinder land	1948	?	Good	Moderate	Fair
	21°29'25"	158°05'50"	1000	40	Kawaihapai	ca.1930	4 acres	Good	Moderate	Excellent
	21°23'40"	157°54'20"	800	50	Manana	ca.1940	4 acres	Fair	Slow	Inferior
	21°21'55"	157°48'25"	1100	130	Lolekaa	ca.1930	4 acres	Fair	Slow	Inferior
Hawaii	19°26'49"	154°51'32"	100	80	Aa lava flow	1951	600 seed	Fair	Moderate	Fair to inferior
	19°38'24"	155°08'50"	1500	200	Kiloa ext.	1948	122	Good	Fast	Fair
	20°11'20"	155°46'15"	1600	110	Niulii	ca.1925	4 acres	Good	Moderate	Inferior
	20°11'00"	155°46'10"	1600	110	Kehena	ca.1925	4 acres	Good	Fast	Excellent
Kauai	21°57'35"	159°31'50"	1400	60	Pooku	ca.1925	4 acres	Good	Fast	Fair
	21°56'50"	159°32'15"	1100	45	Kapaa	ca.1930	4 acres	Good	Moderate	Fair
	21°57'00"	159°31'55"	1600	50	Pooku	ca.1930	4 acres	Good	Fast	Fair
	21°56'50"	159°31'48"	1300	50	Kalapa	ca.1930	4 acres	Good	Fast	Excellent
	21°56'55"	159°30'15"	900	75	Rough broken land	ca.1930	4 acres	Good	Fast	Fair to excellent
	21°55'50"	159°26'30"	400	65	Hihimanu	ca.1925	4 acres	Good	Fast	Fair
	22°10'35"	159°23'30"	700	60	Pooku	ca.1925	4 acres	Good	Fast	Excellent
	22°04'12"	159°21'05"	600	60	Hanamaulu	ca.1940	4 acres	Fair	Moderate	Fair
	22°04'28"	159°21'13"	400	60	Hanamaulu	ca.1940	4 acres	Good	Fast	Fair
	Maui	20°54'35"	156°31'15"	700	40	Rough mountainous	ca.1925	4 acres	Fair	Moderate to fast
Alnus nepalensis (35 P, 43,050 S; O,Mo,M,H; 1930-60)										
Hawaii	20°02'57"	155°40'36"	3600	75	Kahua	1939	3,754	Fair	Moderate	Inferior
	20°03'50"	155°37'50"	3400	100	Kahua	1939	4 acres	Fair to good	Moderate to fast	Inferior to fair
Araucaria columnaris (53 P, 21,949 S; K,O,M,H; 1917-59)										
Hawaii	19°50'02"	155°08'45"	1600	250	Hydrol humic latosol	1923	130	Good	Moderate	Excellent

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			Feet	Inches						
Araucaria columnaris (continued)										
Oahu	21°27'20"	158°05'40"	2200	40	Tropohumults- Dystrandeps Assoc.	1927	1,132	Poor	Slow	Fair
	21°37'30"	157°57'10"	900	90	Kapaa	1929	175	Good	Moderate	Fair
	21°39'20"	158°01'05"	700	60	Kapaa	1926	306	Good	Moderate	Fair
	21°28'10"	157°52'05"	300	90	Waikane	1921	1,000	Good	Moderate	Excellent
	21°28'20"	157°51'55"	500	90	Waikane	1927	3,885	Good	Moderate	Excellent
	21°28'20"	158°07'00"	1100	40	Lualualei	1920	492	Good	Slow	Fair
	21°25'35"	158°06'45"	1000	32	Stony land	1927	2,338	Good	Slow	Fair
Araucaria cunninghamii (13 P, 8637 S; K,O,Mo,H; 1929-59)										
Oahu	21°18'55"	157°48'15"	800	45	Manana	1932	280	Poor	Slow to moderate	Fair
Kauai	21°57'08"	159°31'20"	1400	50	Kalapa	1934	1,000+	Good	Slow	Fair
Brachychiton acerifolium (29 P, 4119 S; O,Mo,M,H; 1921-57)										
Maui	20°52'57"	156°11'58"	700	190	Kailua	1953	?	Poor	Slow	Fair
Callitris calcarata (7 P, 4514 S; K,M,H; 1933-59)										
Maui	20°54'52"	156°16'00"	500	80	Pauwela	1949	4,245	Poor	Moderate	Fair
Callitris glauca (11 P, 1290 S; O,M,H; 1931-57)										
Oahu	21°23'50"	157°54'15"	700	70	Rockland	1935	116	Fair	Moderate	Fair
	21°19'35"	157°48'00"	500	125	Rough mountainous	1933	124	Fair to poor	Slow	Fair
Calophyllum brasiliense (8 P, 295 S; M; 1929-32)										
Maui	20°51'52"	156°10'19"	360	240	Rough mountainous	1931	68	Poor to fair	Slow	Inferior
Castanospermum australe (24 P, 1187 S; K,O,M,H; 1927-57)										
Oahu	21°23'45"	157°54'05"	900	70	Rough mountainous	1927	473	Poor	Slow	Inferior

(Continued)

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and (stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			Feet	Inches						
Cedrela odorata (32 P, 26,000 S; K,O,Mo,M,H; 1924-59)										
Oahu	21°19'10"	157°49'40"	500	75	Rockland	1924	200	Fair	Moderate	Fair
Maui	20°50'53"	156°16'56"	2100	120	Honomanu-Amalu Assoc.	1932	1,065	Fair	Moderate	Fair
Cinnamomum camphora (27 P, 3631 S; K,O,M; 1919-51)										
Oahu	21°19'30"	157°47'50"	600	125	Rough mountainous	1933	532	Fair	Slow	Inferior
Enterolobium cyclocarpum (35 P, 16,067 S; K,O,M,H; 1923-49)										
Maui	20°53'01"	156°13'32"	1200	90	Honomanu-Amalu Assoc.	1936	1,040	Fair	Fast	Fair
	20°53'36"	156°14'58"	1200	170	Rough broken land	1936	1,272	Poor	Moderate	Inferior
	20°52'34"	156°12'38"	1200	170	Honomanu-Amalu Assoc.	1937	323	Fair to poor	Moderate	Fair
	20°52'31"	156°11'18"	600	200	Honomanu-Amalu Assoc.	1954	6	Good	Fast	Excellent
Eucalyptus deglupta (28 P, 4192 S; K,O,Mo,M,H; 1945-58)										
Oahu	21°19'25"	157°47'00"	900	110	Lolekaa	1953	?	Good	Moderate to fast	Fair
	21°19'25"	157°47'05"	800	110	Kawaihapai	1953	?	Good	Fast	Excellent
Maui	20°53'00"	156°12'15"	900	150	Rough mountainous	1954	?	Good	Fast	Excellent
	20°53'10"	156°12'30"	900	150	Kailua	1954	?	Fair	Moderate	Fair
Hawaii	20°04'44"	155°33'30"	2200	90	Honokaa	1950	3	Good	Moderate	Excellent
	19°38'30"	155°05'47"	800	200	Hapai	1957	126	Good	Fast	Excellent
Flindersia brayleyana (21 P, 3815 S; O,Mo,H; 1935-60)										
Oahu	21°19'50"	157°48'55"	1400	110	Tantalus	1935	270	Fair	Moderate	Fair
	21°23'55"	157°54'10"	900	65	Rough mountainous	1935	289	Good	Moderate	Fair
Hawaii	19°38'30"	155°05'47"	800	200	Papai	1957	180	Good	Fast	Fair to excellent

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			<u>Feet</u>	<u>Inches</u>						
Fraxinus uhdei (125+ P, 294,000+ S; K,O,Mo,L,M,H; 1924-60)										
Oahu	21°39'10"	158°01'50"	700	55	Paumalu	1935	?	Poor	Slow	Inferior
	21°27'25"	158°05'35"	1800	40	Tropohumults- Dystrandeps Assoc.	1928	3,364	Fair	Slow	Inferior
	21°18'35"	157°48'10"	1000	45	Manana	1932	925	Poor	Slow	Inferior
	21°23'40"	157°53'05"	1100	70	Rough mountainous	1934	3,780	Fair	Slow	Inferior
	21°24'15"	157°53'55"	1200	85	Rough mountainous	1929	1,005	Fair	Slow	Inferior
Lanai	20°50'30"	156°54'30"	1700	40	Koele	1935	4 acres	Good	Moderate	Fair
	20°50'25"	156°54'30"	1800	40	Koele	1935	4 acres	Fair	Moderate	Fair
	20°49'30"	156°54'10"	1700	40	Koele	1935	4 acres	Good	Moderate	Fair
	20°50'15"	156°54'30"	2000	40	Koele	1935	4 acres	Good	Moderate	Fair
Hawaii	19°29'45"	155°52'20"	3200	80	Kealakekua	1929	1,000	Good	Moderate	Fair
	19°55'00"	155°19'00"	5000	125	Puu Oo	1918	?	Good	Moderate	Fair
Maui	20°48'23"	156°17'10"	3700	55	Olinda	1928	628	Good	Moderate	Fair to excellent
	20°51'01"	156°16'57"	2100	120	Alluvium	1928	614	Good	Moderate	Fair
	20°41'25"	156°20'15"	5200	40	Kaipoioi	1936	?	Good	Slow	Inferior
Grevillea robusta (270 P, 2,242,000 S; K,O,Mo,M,H; 1910-59)										
Oahu	21°25'55"	158°05'00"	1300	35	Tropohumults- Dystrandeps Assoc.	1938	36,000	Good	Moderate	Fair
	21°23'50"	157°54'10"	700	70	Rough mountainous	1927	5,174	Fair	Moderate	Fair
	21°21'30"	157°48'42"	1100	130	Lolekaa	1930	4 acres	Good	Moderate	Fair
	21°23'55"	158°06'00"	2100	35	Tropohumults- Dystrandeps Assoc.	1940	4 acres	Good	Slow	Fair
	21°27'30"	158°05'00"	1900	40	Tropohumults- Dystrandeps Assoc.	1940	4 acres	Good	Moderate	Fair
	21°27'15"	158°05'00"	1700	40	Manana	1940	4 acres	Good	Moderate	Fair
Maui	20°52'26"	156°11'30"	1200	200	Honomanu-Amalu Assoc.	1935	5,568	Fair	Moderate	Fair
	20°48'33"	156°05'37"	800	170	Hana	1939	1,035	Good	Moderate	Fair
	20°48'23"	156°17'12"	3600	55	Rough broken land	1928	214	Poor	Slow	Inferior
	21°01'20"	156°37'14"	200	35	Rough broken land	1949	?	Fair	Slow	Inferior
	20°46'40"	156°14'55"	6900	50	Laumaia	1910	25	Poor	Slow	Inferior

(Continued)



Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			<u>Feet</u>	<u>Inches</u>						
Grevillea robusta (continued)										
Hawaii	19°20'19"	155°27'16"	3500	60	Kapapala	1930	2,208	Fair	Moderate	Fair
	19°57'54"	155°16'50"	2000	150	Kiloa	1925	700	Good	Moderate	Fair
	19°59'55"	155°20'30"	2200	130	Honokaa	1930	4 acres	Good	Moderate	Fair
	19°38'00"	155°08'15"	1300	175	Kiloa	1930	4 acres	Good	Moderate	Fair
	19°46'40"	155°50'45"	2900	35	Rockland	1930	4 acres	Good	Moderate	Fair
	19°45'10"	155°58'30"	2000	40	Kaimu	1930	4 acres	Good	Moderate	Fair
	20°04'45"	155°34'37"	2300	100	Honokaa	1930	4 acres	Good	Moderate	Fair
	20°02'07"	155°26'55"	2400	100	Honokaa	1930	4 acres	Good	Moderate	Fair
Intsia bijuga (9 P, 285 S; O,M; 1917-47)										
Maui	21°00'18"	156°36'27"	200	75	Rough broken land	1935	?	Fair	Moderate	Fair to inferior
Juglans nigra (20 P, 1620 S; M,H; 1932-47)										
Maui	20°48'22"	156°17'00"	3600	55	Olinda	1941	10	Poor	Slow	Inferior
Hawaii	19°51'51"	155°18'25"	5300	120	Piihonua	1942	141	Poor	Slow	Inferior
	19°40'27"	155°52'47"	6200	40	Rough broken land	1942	209	Poor	Slow	Inferior
Lagerstroemia speciosa (24 P, 5200 S; O,Mo,M,H; 1926-57)										
Maui	20°51'36"	156°10'49"	200	90	Rough mountainous	1935	27	Poor	Slow	Inferior
	20°51'08"	156°10'27"	100	240	Rough mountainous	1954	25	Poor	Slow	Inferior
Platymiscium stipulare (19 P, 5600 S; O,Mo,M; 1937-59)										
Oahu	21°24'25"	158°06'45"	1200	30	Stony land	1937	2,625	Good	Slow	Inferior
	21°18'35"	157°45'20"	1000	50	Helemano	1953	133	Poor	Slow	Inferior
	21°27'25"	158°05'25"	1800	40	Tropohumults- Dystrandpts Assoc.	1937	1,028	Fair	Moderate	Fair to inferior
Maui	20°53'21"	156°15'56"	500	80	Kailua	1949	720	Poor	Slow	Inferior
Podocarpus imbricatus (16 P, 460 S; O,Mo,H; 1924-58)										
Hawaii	19°55'26"	155°20'14"	5100	80	Hanipoe	1942	47	Poor	Slow	Inferior
	20°04'44"	155°33'30"	2200	80	Honokaa	1950	38	Fair	Slow	Good
	19°50'05"	155°09'30"	1700	200	Rough broken land	1924	10	Good	Slow	Good

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			Feet	Inches						
Sequoia sempervirens (84 p, 130,000 S; K,O,Mo,L,M,H; 1919-60)										
Kauai	22°08'10"	159°38'35"	3500	60	Kokee	1930	4 acres	Good	Moderate	Fair
Lanai	20°48'55"	156°52'00"	3200	40	Kahanui	1956	3,000	Poor	Slow	Fair
Maui	20°42'05"	156°18'57"	6400	35	Laumaia	1956	12	Good	Slow	Fair
	20°48'17"	156°17'04"	3800	55	Olinda	1930	3,490	Poor	Slow	Fair
	20°41'28"	156°20'04"	5600	40	Kaipoi	1930	18,567	Good	Moderate	Excellent
	20°50'59"	156°17'10"	2100	100	Rockland	1932	1,153	Poor	Slow	Inferior
Hawaii	19°57'25"	155°20'14"	4000	80	Maile	1927	3,604	Poor	Slow	Fair
	19°29'32"	155°52'12"	3100	110	Kealakekua	1927	1,000	Good	Moderate	Excellent
	20°01'43"	155°26'36"	2500	70	Honokaa	1929	41	Poor	Slow	Fair
Swietenia macrophylla (34 P, 7000 S; O,Mo,M,H; 1928-60)										
Oahu	21°34'45"	158°00'55"	700	80	Alluvium	1944	258	Good	Moderate	Fair
Maui	21°00'28"	156°36'28"	200	140	Rough mountainous	1935	?	Good	Moderate	Fair
Hawaii	19°40'00"	155°04'00"	100	150	Papai	1936	161	Good	Slow	Fair
Swietenia mahagoni (37 P, 11,626 S; K,O,Mo,M,H; 1918-58)										
Oahu	21°39'30"	158°00'55"	800	60	Kapaa	1926	250	Poor	Slow	Inferior
	21°39'25"	158°00'55"	700	60	Kapaa	1921-1923	850	Good	Slow	Inferior
	21°24'15"	157°53'55"	1200	85	Rough mountainous	1927	199	Poor	Slow	Inferior
	21°19'20"	157°49'45"	500	75	Kaena	1918	1,484	Good	Slow	Fair to inferior
	21°26'00"	158°06'20"	1000	35	Stony land	1926	1,238	Poor	Slow	Inferior
Maui	20°50'47"	156°16'34"	2400	100	Kailua	1928	2,203	Poor	Slow	Inferior
Tabebuia donnell-smithii (18 P 1237 S; K,O,M,H; 1923-58)										
Hawaii	19°12'35"	155°28'20"	700	40	Naalehu	1924	18	Fair	Slow (18+)	Inferior and fair

(Continued)

(Continued)

Table 1--Forest tree plantings appraised for species adaptability to Hawaii--Continued

Species and location of plantings appraised (lat. N, long. W) <sup>1</sup>			Eleva- tion	Rain- fall	Soil mapping unit <sup>2</sup>	Year planted <sup>3</sup>	Number seedlings planted	Adaptability (survival and stocking) <sup>4</sup>	Height growth <sup>5</sup>	Form <sup>6</sup>
			Feet	Inches						
Terminalia myriocarpa (64 P, 26,339 S; K,O,M,H; 1928-58)										
Oahu	21°22'10"	157°50'30"	500	110	Lolekaa	1950	170	Fair	Moderate	Inferior
	21°20'15"	157°49'15"	1500	120	Tantalus	1948	205	Fair	Moderate	Fair
Hawaii	19°38'30"	155°56'13"	2300	90	Honaunau	1929	258	Fair	Moderate	Inferior and fair
	19°38'00"	155°09'13"	1500	200	Keef	1929	180	Fair	Moderate	Inferior
	19°57'20"	155°20'16"	4000	80	Maile	1936	2,921	Good	Slow	Inferior
	20°04'40"	155°33'30"	2200	70	Honokaa	1945	418	Good	Moderate	Inferior
	20°11'25"	155°46'35"	1600	75	Niulii	1929	454	Good	Moderate	Inferior
	19°29'28"	155°52'03"	3200	110	Kealakekua	1936	500	Good	Moderate	Inferior
	Toona ciliata var. australis (178 P, 190,000 S; K,O,Mo,L,M,H; 1917-60)									
Oahu	21°24'00"	157°54'10"	1000	65	Rough mountainous	1924	260	Poor	Slow	Inferior
	21°31'25"	157°58'55"	1100	60	Rough mountainous	1929	710	Fair	Moderate	Fair
	21°39'15"	158°01'00"	800	60	Kapaa	1920-1924	3,364	Poor	Slow	Inferior
	21°34'45"	158°00'55"	700	80	Alluvium	1943-1944	235	Good	Moderate	Fair
	21°19'10"	157°49'40"	500	75	Rockland	1920-1924	2,380	Fair	Slow	Fair
	21°19'30"	157°49'05"	1300	100	Tantalus	1921-1922	664	Fair	Moderate	Excellent
	21°20'00"	157°48'55"	1500	120	Tantalus	1926	385	Fair	Moderate	Fair
	Lanai	20°49'45"	156°54'15"	1800	40	Rough mountainous	1935	?	Fair	Moderate
20°50'55"		156°54'25"	1700	40	Koele-Badland complex	1935	?	Good	Moderate	Excellent
Maui	20°48'23"	156°17'16"	3500	50	Olinda	1928	2,450	Good	Moderate	Fair
	20°50'57"	156°16'50"	2100	120	Alluvium	1928	75	Poor	Slow	Inferior
	20°50'54"	156°16'54"	2100	120	Kailua	1928	?	Fair	Moderate	Fair
	20°41'25"	156°20'15"	5300	40	Kaipoi	1936	?	Poor	Slow	Inferior
	20°49'03"	156°08'28"	1400	240	Rough mountainous	1936	18,040	Fair	Moderate	Fair
	Hawaii	20°02'31"	155°36'23"	2900	60	Maile	1923	300+	Fair	Moderate
19°29'30"		155°52'03"	3200	110	Kealakekua	1935	500	Good	Moderate	Excellent
19°38'28"		155°55'59"	2600	90	Honaunau	1928	609	Good	Moderate	Fair

For footnotes see page 13.

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